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A. C. True, Director.

THE RESPIRATION CALORIMETER: APPLICATION TO THE STUDY OF PROBLEMS OF VEGETABLE PHYSIOLOGY.

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To aid in the study of special problems of interest to the Department of Agriculture, an instrument of precision—the respiration calorimeter—was devised in connection with the nutrition investigations of the Office of Experiment Stations. With this instrument and its accessory apparatus it is possible to measure at one and the same time and very accurately a number of important factors and to secure experimental data not otherwise readily obtainable.

In reconstructing the apparatus in the new laboratory building of the department, changes were made which greatly simplified and improved its operation. This is particularly true of devices which have been introduced for automatically controlling the temperature of the water flowing through the calorimeter, which carries out the heat generated in the chamber, and for automatically recording the difference in temperature of the water as it enters and as it leaves the chamber. These improvements and new accessory devices make for ease, accuracy, and economy of operation.

The large calorimeter, with a respiration chamber 6½ feet long, 4 feet wide, and 6½ feet high, has been employed chiefly for experiments with man. The experiments include the determination of the balance of income and outgo of matter in terms of carbon, hydrogen, oxygen, and nitrogen, and of energy measured as heat. The factors specifically measured with the respiration calorimeter are carbon dioxid and water outgo, oxygen consumption, and energy (heat) outgo, and numerous ratios between these quantities or their elements. As yet mineral matter has not been studied in detail in work of this character, except to meet the requirements of particular experiments.

The experiments cover periods ranging from a few hours to a few days. Suitable control experiments have demonstrated the accuracy of the apparatus. The respiration chamber is equipped with a cot and other devices for the convenience of the subject, and the experiments involve no physical discomfort, an important matter in order that the results obtained may represent normal conditions.

Recent experiments have to do with the energy expended by the body in digesting cheese in comparison with a comparable amount of meat as part of a simple mixed diet. The results do not indicate that

marked differences exist in the ease of digestion of these foodstuffs under such conditions.

During the past year a new line of investigations has been undertaken with the respiration calorimeter, which marks a departure in studies of this kind and indicates a broader application of the experimental method. These newer experiments have to do with problems connected with the ripening of fruit and have shown that the apparatus is applicable to such studies. Several bunches of bananas were placed in the respiration chamber and kept under observation during the active ripening process, which was completed to the usual commercial stage. During this time the oxygen consumption, the carbon dioxid excretion, and the heat elimination were determined. The data obtained indicate that physical and chemical factors of great value in the study of this problem, which is of both practical and theoretical importance, can be accurately measured with the respiration calorimeter.

It has been found very desirable, however, to employ a smaller respiration chamber for such work, since it involves the handling of smaller quantities of fruit and a better control of experimental conditions. Consequently a respiration calorimeter more suited in size to these particular investigations has been constructed in which the respiration chamber is 18 by 18 by 36 inches in size. Recording and controlling devices of special construction involving much that is new and original have been used in this apparatus to such an extent that the calorimeter will be very largely automatic in operation and can be operated at the same time and by the same observers as are employed upon the other calorimeter in experiments with man.

The work thus far done with ripening fruits was undertaken in cooperation with the Bureau of Chemistry of this department, and it marks the adaptation of the respiration calorimeter to a wider field of investigation in which it has not hitherto been employed and in which investigations have not been numerous owing to a lack of adequate methods. It has demonstrated that the instrument is fully as well suited for the study of certain fundamental problems of plant life as it is for the study of similar problems of animal life. Plans are already under consideration for experiments on a variety of such problems, with the object of securing data needed in projects which the Department of Agriculture has under investigation.

The apparatus can be used in similar ways in studying such problems as the changes which take place when meat or cheese or other farm products are cured or ripened and factors which influence these changes—problems which are of commercial interest as well as of agricultural, domestic, and scientific importance.

The small respiration calorimeter has been so constructed that with a little modification of the metal-walled respiration chamber it can

be used for experiments with small animals as subjects should cooperative work between bureaus of the department make this desirable. As is the case in the respiration-calorimeter experiments with men as subjects, ample provision can be made for the comfort of the animals in such experiments, in order that the results may be normal.

It would be particularly useful to study by these methods the influence of heat and of a moisture and carbon-dioxid effect of the air upon eggs during incubation by a hen and by artificial methods, and also to study in detail the respiratory and energy changes of incubating eggs.

A microcalorimeter for use in the experimental study of very small quantities is being installed. With it some of the details of fruit-ripening problems now under investigation can be advantageously studied. This piece of apparatus materially extends the possibilities of studying agricultural problems by calorimetric methods, but involves little that is new in the way of equipment, since the recording and controlling devices already in use with the larger calorimeters serve for this kind of work also.

Back of all practical applications there must be scientific work if conclusions are to endure, and this is as true of agriculture as of other branches of science. The investigator who seeks the solution of a problem very commonly bases his conclusions upon the changes which take place when the chemical substance or the plant or the animal which he is studying is observed under controlled experimental conditions. It is because of this that the respiration calorimeter, which permits of the measurement at one time and with great accuracy of many factors, is of so much importance.

The Department of Agriculture is now well equipped with calorimeters of great accuracy, adapted to many uses, and with this equipment is engaged in the study of a variety of problems of interest to the farmer and to those who use his products.

Recommended for publication.
A. C. True, *Director.*

Publication authorized.
James Wilson, *Secretary of Agriculture.*

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